# A METHOD AND AN APPARATUS FOR FRICTION MEASUREMENT

This invention relates to monitoring systems and in particular to a method and apparatus for measuring belt friction.

The invention provides a method of measuring the friction of a surface of a belt in a pulley and belt assembly, comprising the steps of applying a movable member to a surface of the belt, applying a thrust to the movable member in a sense to tend to move the movable member relative to the belt over its said surface, and obtaining a measure of the thrust needed to initiate slippage between the movable member and the belt, whereby to provide a measure of the friction of the said belt surface.

The invention also provides apparatus for measuring the friction of a surface of a belt in a pulley and belt assembly, comprising means for applying a movable member, eg a rotatable disc, to a surface of the belt, means for applying a thrust, eg a counter-torque, to the movable member in a sense to tend to move the movable member relative to the belt over its said surface, and means for obtaining a measure of the thrust needed to initiate slippage between the movable member and the belt, whereby to provide a measure of the friction of the said belt surface.

By way of example, embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic illustration of apparatus according to the invention,

Figure 2 is a typical plot from simple operation of the apparatus of Figure 1, and

Figure 3 is a typical plot from a repeating operation of the Figure 1 apparatus.

In Figure 1, numeral 10 designates apparatus for measuring the coefficient of friction of the surface of a belt 11 in a pulley and belt assembly. The term "pulley and belt assembly" as used herein is intended to include any kind of assembly where an elongate flexible member ("belt") is driven around two or more rotatable members ("pulleys"), whether for the purpose of delivering rotational drive from one shaft to another or for the purpose of conveying items such as parcels or letters. However, the invention is particularly useful for letter conveying assemblies, also known as transport belts, which convey letters whilst they are orientated in a vertical plane and where belt friction is a vital factor in the conveyor's efficiency.

The apparatus 10 comprises a disc 12 which is rotatably mounted on a bracket 13. The outer rim of the disc 12 is designed to be in contact with the surface of the belt 11. For this purpose, the bracket 13 may conveniently be mounted on a frame or other suitable structure 14 on or adjacent to the machine in which the pulley and belt assembly is incorporated. The disc 12 is preferably arranged to contact the belt 11 at a point where it is trained over a pulley 15, so that the belt is nipped between the disc and pulley. The bracket 13 preferably incorporates an adjustable spring-loaded mechanism 16 to allow the nip pressure on the belt 11 between the disc 12 and pulley 15 to be set and remain at a constant chosen value.

The disc 12 will normally be driven to rotate through its contact with the moving belt 11, and the surface texture of the outer rim of the disc and the nip pressure are suitably chosen for this purpose. A measurable braking or restraining device, such as an electric motor 17, is coupled to the disc 12 in order to provide a counter-torque to oppose its rotation. The motor 17 is conveniently mounted on the bracket 13. A sensor 18 is arranged to detect rotational movement of the disc 12. Signals from the sensor 18 are transmitted to a data processing unit 19. The motor 17 is controlled by the data processing unit 19.

In dynamic use of the apparatus 10, with the belt 11 moving and driving the disc 12 to rotate, the motor 17 is used to apply a controlled counter-torque to the disc, ie in a sense opposing rotation of the disc. The counter-torque from the motor 17 is increased until it is just sufficient to stop the disc 12 rotating. This will be detected by the sensor 18 and this is the point at which the frictional force between the belt 11 and disc 12 is overcome. The value of the load on the motor 17 at this instant (at reference $t_o$ in Figure 2) can be used to give a measure of the static friction of the belt 11.

Once relative movement starts to occur between the belt 11 and disc 12, ie slippage, less counter-torque from the motor 17 will be required to stop the disc 12 rotating. This is the kinetic friction of the belt 11, which settles at a generally constant lower value, as is seen in the curve to the right-hand side of $t_o$ in the Figure 2 plot.

The data processing unit 19 is advantageously programmed to control the apparatus so that it operates on a continuous basis, somewhat akin to the principle used for anti-lock braking systems. This will now be described with reference to Figure 3.

At a given instant $t_1$, if the signal from the sensor 18 indicates that the disc 12 is still being driven by the belt 11, the data processing unit 19 increases the load on the motor 17 and hence the counter-torque applied to the disc. Such an instant would for example be at point (a) in Figure 2. If, in another instant $t_2$, the signal from the sensor 18 indicates that the disc 12 has momentarily been brought to rest, the data processing unit 19 immediately reduces the motor load and hence the counter-torque applied to the disc. Such an instant is represented as point (b) in Figure 3. Because the system will take a finite time to react, there will for a moment be a certain amount of slippage between the belt and the momentarily-stationery disc. This is represented by the

downwardly sloping curve (c) in Figure 3. As soon as the signal from the sensor indicates that the disc has once again begun to be driven to rotate by the belt, however, the data processing unit will once again increase the motor load to produce enough counter-torque to stop the disc. This is represented by the upwardly sloping section (d) of the plot in Figure 3. A point is again reached where the disc is brought momentarily to a standstill, indicated here as point (e) at instant $t_3$. The system continues in this cyclical manner, continuously monitoring and giving a measure of belt friction.

The apparatus 10 will preferably be able to monitor belt friction at various different positions on the belt, say for example at the top, bottom and middle sections of the belt seen in Figure 1. For this purpose, a number of individual discs may be used. Alternatively, the apparatus 10 may be mounted so as to be movable relative to the belt, parallel to the axis of the pulley 15 seen Figure 1, with a single disc thereby being capable of sampling belt friction at different locations across the width of the belt.

The apparatus could of course be used to measure the static friction of the surface of a belt when the belt is stationery.

It will be appreciated that whereas an electric motor has been used in the apparatus described above, other measurable braking or retraining means could equally well be used instead. Indeed, mechanisms other than the rotatable disc may be used as a means of measuring friction.

The apparatus 10 will preferably be capable of operating autonomously on a continuous basis and thereby provide a constant watch over the condition of the belt.